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Statement of
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Committee on Science and Technology
U.S. House of Representatives

Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to appear today to discuss the President's FY 2008 budget request for NASA's Earth Science program. You have previously heard from the new Associate Administrator for the Science Mission Directorate (SMD), Alan Stern, on his general plans for the entire Directorate, in particular in the area of Space Science, and I welcome this opportunity to discuss specifically the important area of Earth Science, especially in light of the recently released National Research Council's (NRC's) Earth Science Decadal Survey.

In your letter of invitation, you asked that I address my priorities for the Earth science program in the coming years, as well as the plan for meeting these objectives. My primary objective for the Earth Science Division is to expand the leading role of NASA measurements and NASA-supported analyses in advancing Earth System science – improving our quantitative understanding of the Earth as an integrated system. To reach this goal, we will reinvigorate the flight portfolio by soliciting, implementing, launching, and operating new cutting-edge flight missions; we will work with the National Oceanic and Atmospheric Administration (NOAA) and other national and international operational agencies to hasten transition processes so that measurements pioneered and proved by NASA will be subsequently acquired by operational satellite systems over the multi-decadal periods required to detect climate signals; and we will preserve and expand the pre-eminent research and analysis, applied sciences, technology development, and educational programs that distinguish the NASA Earth Science endeavor. The recently released NRC's Earth Science Decadal Survey provides specific guidance in these areas, and the FY 2008 budget request along with planned interagency and international working group activities will allow us to advance toward these objectives.

NASA's FY 2008 budget request includes $1.5 billion for the study of planet Earth from space. This represents an increase of $32.8 million over the FY 2007 budget request (adjusted for full-cost simplification and the new theme structure of the budget). The FY 2008 request will fund a wide-ranging and balanced program of activities, including:

- Developing, launching, and operating Earth-observing space missions;
- Competitively selecting and pursuing research and analysis science investigations conducted by NASA and non-NASA researchers;

- Conducting Applied Science projects that help other federal and regional agencies and organizations to efficiently use products from NASA Earth research to advance their missions;
- Soliciting and advancing technology development efforts to enable the missions of the future; and,
- Providing education and public outreach programs to make our knowledge of the Earth accessible to the world.

NASA's budget request supports a balanced program, allocating over 30 percent of NASA's request for the Science Mission Directorate and, within the Science Mission Directorate, allocating 27 percent of funding for Earth Science.

Much of the science community's present state of knowledge about global change – including many of the measurements and a significant fraction of the analyses which serve as the foundation for the recent report of the Intergovernmental Panel on Climate Change (IPCC) – is derived from NASA's Earth Science program. For example, using data from Earth observing satellites NASA-supported researchers are: monitoring ice cover and ice sheet motions in the Arctic and the Antarctic; quantifying the short-term and long-term changes to the Earth's protective shield of stratospheric ozone, including the positive impacts of the Montreal protocols; discovering robust relationships between increasing upper ocean temperature and decreasing primary production from the phytoplankton that form the base of the oceans' food chain; and, using a fleet of satellites flying in formation (the "A-Train"), making unique, global, near-simultaneous measurements of aerosols, clouds, temperature and relative humidity profiles, and radiative fluxes.

Our improved understanding of Earth System processes leads to improvements in sophisticated weather and climate models, which, in turn, – when initialized using the satellite data – can be used to predict natural and human-caused changes in the Earth's environment over time scales of hours to years.

Importantly, near-real-time measurements from NASA research missions (including the Tropical Rainfall Mapping Mission (TRMM), the Quick Scatterometer (QuikSCAT), the Atmospheric Infrared Sounder instrument on the Aqua mission, and others) are used routinely by NOAA and other U.S. and international agencies to improve weather forecasting. Similarly, high quality measurements obtained by NOAA's operational weather satellites provide essential context for the scientific analyses of the NASA research mission data. There is thus a strong synergy between our Nation's research satellites and our operational spaceborne systems. NASA works closely with the other Federal agencies – specifically NOAA – responsible for forecasting to transition these research capabilities to long-term operations as the technologies are demonstrated and matured. As we speak, NASA is operating 14 Earth observing missions. Five more missions are quite far advanced in their development, and will be launched in 2008 and 2009. Of these, the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) and the Ocean Surface Topography Mission (OSTM) will continue critical Earth System and climate measurements that were initiated by the Earth Observing System (for NPP) and the TOPEX/Poseidon and Jason-1 missions (for OSTM). The Glory mission will fly an instrument to extend our measurements of total solar irradiance, as well as an instrument that will provide unique, first-ever measurements of properties of atmospheric aerosols. The Orbiting Carbon Observatory (OCO) and the Aquarius mission will make new, first-of-a-kind global measurements of atmospheric carbon dioxide concentrations and ocean surface salinity – both parameters of known importance to the study of climate change.

The FY 2008 budget request also funds the reconstituted Landsat Data Continuity Mission (LDCM) for launch in 2011. I am pleased to report that the procurement activities for the LDCM are on track. We recently announced the selection of four contractors to study how their spacecraft could accommodate the LDCM Operational Land Imager instrument. Final results are expected this fall. The FY 2008 budget funds the Global Precipitation Measurement Mission (GPM) for launch of its Core spacecraft not later than 2013, followed a year later by launch of the NASA GPM Constellation spacecraft. Extending the pioneering rain measurements initiated with the joint U.S./Japanese TRMM and providing a calibration standard for several other rain-measuring instruments orbited by others, the GPM mission will provide us with accurate, global rain measurements every three hours – much more frequently than is currently possible. Knowledge of accurate rainfall rates and atmospheric water quantities is essential for the study of the Earth's hydrologic cycle and its sensitivity to climate change. In addition, the GPM measurements will be used by operational weather prediction agencies around the globe to improve weather forecasts and severe storm predictions.

As a complement to the research and analysis activities which improve our understanding of the Earth system, the Applied Sciences Program evaluates NASA Earth science data, results, and technology for their potential to serve society beyond their original scientific purpose. Where appropriate, the program accelerates the broader use of these Earth science research results by partnering with Federal agencies and other organizations to test whether NASA results can improve decision making and resource management. In many cases, the demonstrated improvements continue to be used by our partners in their operational decision support systems, after the NASA Applied Sciences project ends.

We have had many recent successes across a broad range of societal benefit areas. I will touch here on examples in the areas of air transportation, regional environmental management, and natural disasters. NASA is working in partnership with the Federal Aviation Administration, NOAA's National Weather Service, and the National Center for Atmospheric Research to ensure safe and efficient air travel for the American public through enhancements to aviation weather forecasting. Weather is a contributing factor in approximately 30 percent of all aviation accidents and accounts for over 60 percent of all delays experienced in the air transportation system. Weather delays in air travel cost the American public over $4 billion per year. By incorporating new, NASA-developed algorithms, observations, and predictive capabilities into aviation weather forecasts, more accurate, dependable, and useful forecasts of threats to aviation including icing, turbulence, convection, and volcanic ash can be made. For example, NASA recently released results that suggest the incorporation of improved satellite observations and new algorithms into a decision support tool for thunderstorm initiation often enhance performance by providing a detailed analysis of the locations and early growth of non-precipitating convective clouds. One newly developed parameter showed an 84 percent probability of detection of convective initiation over a thirty minute window.

In terms of improving regional environmental management with techniques deployable both in the United States and abroad, NASA is partnering with U.S. Agency for International Development and other U.S. and Latin American government agencies and nongovernmental organizations to develop, operate, and refine an environmental monitoring and visualization system for the entire isthmus of Central America. Known as SERVIR, this system is web-based and provides satellite- and ground-based geospatial data for management and decision support. In addition to a data archive, Internet mapping tools, and visualization software, SERVIR offers a number of decision support products including those for fires, floods, harmful red tide events, developing climate scenarios, and weather forecasting. Examples of recent activities are the use of SERVIR imagery by fire fighters in northern Guatemala to battle fires and national park managers

in Belize employing SERVIR fire alerts to detect unauthorized incursions and clearing of tropical forest within the Chiquibul National Park. The SERVIR web location is http://servir.net/.

Another recent NASA Applied Science program contribution was our real-time support to state emergency responders in the Esperanza fires last October in California. A data integration tool developed under Applied Science's Wildfire Research and Applications Partnership or WRAP (NASA, USFS and the National Interagency Fire Center), together with a 16-hour emergency flight of a NASA Ames UAS (Unmanned Aerial System), provided invaluable real-time information about fire location, intensity, and extent that was used to guide the California Governor's Office of Emergency Services and the Esperanza Fire Incident Command Center as they battled the fire. The WRAP integration tool incorporates data and technology from an array of sources, both public and private, and displays the data on a Google Earth software base. In collaboration with the U. S. Forest Service, the WRAP project continues to be supported by the Earth Science Division's Research and Analysis and Technology Programs to further test the integrated UAS system during actual wildfire events this coming fire season in California.

In March, 2007, the NASA Administrator submitted to Congress the report on the Applied Sciences Program's planning, selection, and review processes in Accordance with Section 307 of The National Aeronautics and Space Administration Authorization Act of 2005 (P.L. 109-155) ("the Act"). In this year's Research Opportunities in Space and Earth Sciences (ROSES) research announcement, we explicitly incorporated the requirements of Section 313 of the Act, which identifies the need to address State, local, regional and tribal agency needs and to utilize both NASA and commercial sector capabilities. Specifically, the Applied Sciences Program requires grantees to utilize commercially available products whenever it is appropriate and available, consistent with NASA Earth science policy. The Applied Sciences Program, under new leadership, is planning a comprehensive review of the program to ensure that it is aligned with the NAS Decadal Survey recommendations and is working with NASA leadership to establish an appropriate advisory structure, in accordance with Section 314 of the Act.

Even as we are acquiring and analyzing measurements today, we are planning the satellites, field experiments, scientific investigations, and Earth System models of the future. The recently released Earth Science Decadal Survey provides, for the first time, a scientifically based, community consensus statement of the top priority future Earth System Science problems to be addressed, and it suggests a sequence of notional missions whose measurements could contribute to advancing our understanding of the Earth and its environment.

We welcome the Decadal Survey – indeed, we asked for it. NASA, along with NOAA and the U.S. Geological Survey (USGS), requested and funded the NRC to conduct this first Decadal Survey in Earth science. We formally made the request in the fall of 2003 and the study began in earnest in 2004. The massive undertaking was only completed this January. We are grateful for all of the efforts of the Co-Chairs and NRC staff, the members of the decadal survey Executive Committee, and the literally hundreds of Earth Science researchers who volunteered their time and their ideas. Their success in creating a broad consensus is a substantial achievement.

The science priorities identified by the Decadal Survey will be our primary guide as we design and select Earth observing missions to be flown in the next 10-15 years. In the space sciences, NASA has a long history of guidance by NRC decadal surveys. Indeed, even in the Earth sciences, where this is the first Decadal Survey, the President's FY 2008 budget request for NASA was guided by recommendations included in the interim report issued by the Decadal Survey committee in 2005. The FY 2008 budget request includes funding and predictable launch dates for the LDCM, the

Glory aerosol and solar irradiance mission, NPP, and GPM, all of which figured strongly in the interim report.

Unfortunately, the full Decadal Survey arrived too late for its specific recommendations to influence the FY 2008 budget process, but its scientific priorities will be used in development of the FY 2009 and subsequent budget requests. NASA's FY 2008 budget request also includes funding for an additional, competed flight mission, which will launch sometime around 2014. We will be guided by the Decadal Survey as we choose the scientific focus and instrument complement for this mission, starting with a competitive solicitation in late 2008.

In addition to its science priorities and the notional mission set, the Decadal Survey provides several recommendations relevant to the design and implementation of the Earth Science flight program. Survey recommendations in the areas of international collaboration and technology investment deserve particular consideration.

We all recognize that a constellation of missions and many simultaneous measurements – such as those obtained by the A-train spacecraft described above – are needed to understand the interactions between Earth system processes. No agency or nation can afford to develop and fly all necessary missions single handedly.

The Decadal Survey emphatically recommends international collaboration, to maximize humankind's benefits from our net investment in Earth science, and to avoid unnecessary duplication. To this end, we have already begun discussions with our closest international space agency partners: the Canadian, European, French, Japanese, and German space agencies. Throughout the spring and early summer, we held 8 substantive bilateral meetings with international space agency partners to identify and refine areas of common interest and complementary expertise. We are also actively engaged – indeed NASA and the United States are leaders – in international coordination bodies such as the Committee on Earth Observation Satellites (CEOS) and the international Group on Earth Observations (GEO). As with our present OSTM, Aquarius, and GPM missions, we anticipate substantial joint projects with international partners as we construct missions to address the Decadal Survey's science questions. As a result of this Spring's activities, we are establishing several bilateral, focused, technical-level working groups to refine science investigations, measurement techniques, and programmatic collaboration approaches for some early- and mid-term Decadal Survey missions where clear partner interest and expertise exists.

NASA works closely with other Federal agencies to support an integrated Federal program of climate research. As noted above, the Decadal Survey was jointly requested by NASA, NOAA and the USGS and assigns some priority missions to NASA, and some to NOAA for execution. NASA's contribution to the U.S. Climate Change Science Program (CCSP) is unchanged from the FY 2007 to FY 2008 budget request, and remains the largest single contribution to the Program. Consistent with the Space Act and the 2005 NASA Authorization Act, NASA's role within the broader federal program is guided by the US National Space Policy, authorized by the President in August, 2006. In particular, NASA works closely with NOAA to transition mature and proven measurement capabilities to long-term operations.

Science-driven technology investment is one of the keys to the design and implementation of any future mission set. It is essential to have the technology developed and tested in a relevant environment prior to the approval of any mission. This helps to avoid cost overruns that occur when problems arise with a new technology late in the mission development cycle. To foster

advanced technologies for Earth science, NASA's strategy is two pronged, as recommended by the Decadal Survey, with both focused technology and core technology elements.

Where we know the missions we want to implement and what new technologies are required on a certain schedule, we make focused investments to assure technologies are available when we issue competitive solicitations for mission formulation and development. This is done through the highly successful Instrument Incubator Program, funded under the Earth Science Technology Office, which matures instrument technologies for future measurements.

The second prong addresses the seed corn or "core technologies," for advanced Earth observing missions of the future. Where we know that certain classes of technologies are needed for the types of measurements we would like to make in the future, or are simply convinced that investment in certain sensor or detector technology areas will yield fruit, we will issue open, competitive solicitations for the best ideas. Examples include advanced component development (which allows scientists and technologists to take an idea from the concept to the bench top demonstration stage), laser risk reduction (which has developed fundamental lidar technologies applicable to multiple NASA missions), and advanced information systems technology development (which provides advanced operations technologies which aid in reducing future mission costs).

The Decadal Survey, the U.S. Climate Change Science Program, and NASA's own planning in Earth science all assume the presence of an operational system of environmental monitoring satellites that can make climate-quality measurements. The Nation needs such a system. That is why NASA, along with NOAA and the Air Force, is a member of the NPOESS governing body, and why NASA entered into a partnership with the NPOESS Integrated Program Office to develop NPP. NPP is designed both to continue essential measurements from NASA's Earth Observing System satellites as well as provide a demonstration of instruments to be flown on NPOESS.

The Nunn-McCurdy certified NPOESS program, as you are aware, focuses NPOESS on its weather mission and deletes many of the capabilities previously planned for climate science. As the Decadal Survey committee was finalizing its notional mission set and sequence, the full impact of the removal of the climate sensors from the NPOESS program was just coming to light. Since last summer, we in NASA have been working closely with NOAA, OSTP, and the scientific research community to understand and rank the impacts of these programmatic perturbations, and to develop realistic mitigation scenarios for the most important measurements. This is being done on an accelerated schedule to inform the development of the FY 2009 budget request. In addition to our agency-based technical evaluations and preliminary mitigation strategy designs, NASA and NOAA commissioned, supported, and participated in an NRC workshop which was held last week after several weeks of community planning (including members of the original Decadal Survey committee). The workshop was chartered to examine the scientific and research-focused impacts of the programmatic changes to NPOESS and to consider various recovery scenarios. We are eagerly awaiting the workshop report, expected later in the summer, again in time to provide recommendations useful for helping to determine the FY 2009 budget.

I am pleased to report that, in an initial step, NASA and NOAA have agreed to share equally the cost to restore the Ozone Mapping and Profiler Suite (OMPS)-Limb to the NPP satellite set to launch in 2009. The OMPS Limb will measure the vertical distribution of ozone and complements existing NPOESS systems, in particular the OMPS-Nadir instrument, which continues the long global time series of total column ozone. The first-ever combination of total and vertically resolved ozone measurements will provide scientists unique insight into the dynamical and chemical processes which regulate atmospheric composition.

Considering both the guidance from the Decadal Survey and the realities of the recent programmatic changes to NPOESS, NASA is proceeding with a mission planning activity to determine the focus and content of our specific future Earth observing missions. The plan will integrate the scientific recommendations and priority/sequence of the Decadal Survey, the joint and ongoing NASA-NOAA and community examinations of the NPOESS Nunn-McCurdy changes, and the contributions of our international partners. Through a series of concept studies conducted at NASA Centers, we are carefully examining the Decadal Survey's notional missions. The studies are assessing the technological readiness, system engineering challenges, and expected costs (including support for scientific validation and analysis of the mission data) of each notional mission. These concept studies are accessing the full capability of the NASA mission design and costing apparatus, to complement the estimates assigned by the NRC. We have organized and broadly announced four community workshops, one for each of the four early-term missions assigned to NASA in the NRC's Decadal Survey. The two aims of each workshop are to define the full range of scientific capabilities of each of the synthesized missions recommended by the Decadal Survey, and to identify essential contextual measurements that must also be present in order to advance the science priorities identified in the Decadal Survey. The workshops should provide great community insight into, and recommendations for, these early missions and will aid the subsequent detailed mission design work. These first four workshops will be held during late June and through July – indeed, the workshop focused on the notional "IceSat-II" mission is being held near Baltimore yesterday, today, and tomorrow. As our NASA planning evolves, community involvement will be assured through many more workshops, regular interactions with the Earth Science Subcommittee of the NASA Advisory Council, as well as discipline- and science-focus theme working groups which regularly inform our plans and examine our progress within the NASA Earth Science Division.

The planning process also includes an update later this year to the NASA Earth Science Plan. Indeed, when the Congress asked the Agency for a Science Plan in the NASA Authorization Act of 2005 (P.L. 109-155), you recognized that the Decadal Survey would not be available in time to influence the Earth Science portion of that Plan. Therefore, NASA was asked to describe how it might revise that Plan based on the Earth Science Decadal Survey. Our planning activity and the Science Plan will address that question. We have developed and are presently examining a draft of the Science Plan changes, and expect to begin vetting a refined version through the NRC and NASA Advisory Council committees by the September time frame.

While the scope and specificity of the planning activity clearly must exceed that of the Decadal Survey and must accommodate issues of programmatic balance and national needs, it is definitively not our intention to redo the Decadal Survey or to change the scientific priorities that it identified.

As with decadal surveys in other parts of the Science Mission Directorate portfolio, this Decadal Survey is only the starting point. However, Earth Science planning is even more complex than in other divisions, given the web of partnerships, the many and diverse users of Earth science data, and its societal impact. Considering the long time horizon in the NRC's report, it will require several budget cycles to implement the program that we will derive from the Decadal Survey's near- and mid-term recommended mission sets. Nevertheless, our planning process starts with the consensus scientific priorities articulated for us by the NRC. So I will close by re-iterating my gratitude to the Decadal Survey committee Co-chairs and members for their excellent work. NASA's commitment to Earth Science research is commensurate with theirs.

I welcome your questions on NASA's Earth science program.

Table 1

NASA Earth Science Missions Currently in Development

NPOESS Preparatory Project (2009) Strategic mission; Systematic measurement	Ensures continuity of several key climate measurements between the Earth Observing System and NPOESS. Implementation of the NPOESS Presidential Decision Directive of 1994. Joint mission with the NPOESS Integrated Program Office.
Landsat Data Continuity Mission (2011) Strategic mission; Systematic measurement	Ensures continuity of long-term global land cover change data. Post-LDCM land imagery acquisition by an operational agency is planned. Joint mission with USGS.
Ocean Surface Topography Mission (2008) Strategic mission; Systematic measurement	Ensures continuity of ocean altimetry data; planned as part of a transition to operational agencies. Joint mission with NOAA, CNES & EUMETSAT.
Glory (2008) Strategic mission; Initializes a systematic measurement	Addresses high priority objective of the U.S. Climate Change Science Program. Measure global aerosols & liquid cloud properties and solar radiation. Mandated by the Presidential Climate Change Research Initiative of 2001.
Orbiting Carbon Observatory (2008) Competed mission; Earth System Science Pathfinder	Nearing completion of development. First global measurement of CO_2 from space; small Earth science mission.
Aquarius (2009) Competed mission; Earth System Science Pathfinder	In advanced stage of development. First global measurement of sea surface salinity from space; small Earth science mission. Joint mission with Argentina.
Global Precipitation Measurement (2013) Strategic mission - Initializes a systematic measurement	Recommended by 2005 interim report of decadal survey committee; extend spatial coverage to global and temporal coverage to every 3 hours with constellation
Earth System Science Pathfinder; TBD (2014) Competed mission	*Focus and relative priority to be determined using decadal survey;* solicitation no earlier than 2008 for 2014 launch.